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joint part, inner joint part) of TBJ joints and to define suitable devices for carrying out such machining processes.

[0005] A first solution is a process for machining in a chip forming way outer joint parts and inner joint parts of constant velocity universal ball joints which comprise a longitudinal axis Aa, Ai and a number of ball tracks, wherein the balls tracks are circumferentially arranged in pairs whose track center lines are positioned in planes E₁, E₂, E₃, E₄ extending parallel relative to one another, wherein the pairs of tracks each are machined by rotating disc tools whose axes of rotation R intersect the respective longitudinal axis Aa, Ai perpendicularly at a distance from one another and are held and guided coaxially relative to one another. It should be appreciated that the process referred to here is able to reduce the machining times as compared to previous processes wherein each ball track had to be machined individually, because the number of re-clamping operations as well as the number of machining processes is halved.

[0006] According to a particularly advantageous embodiment, during the chip-forming machining operation, the outer joint parts and inner joint parts respectively are guided linearly in the direction of their respective longitudinal axis Aa, Ai and that the axes of rotation of the disc tools 16, 26 during the chip-forming machining operation are guided synchronously in a linear or pivoting movement radially relative to the respective longitudinal axis Aa, Ai. In this way, the movement sequences are considerably simplified, so that, at a later stage, simply designed devices for carrying out the process can be provided.

[0007] Furthermore, at least two pairs of ball tracks – more particularly radially opposed pairs of ball tracks – can be machined simultaneously. The number of re-clamping operations and the number of machining operations can again be reduced. The process referred to here applies to joint part of joints with four, six or eight pairs of tracks.

[0008] Equally, the method provides – with reference to a simplified design of the devices to be used - that the disc tools are driven in pairs at identical speeds.

[0009] A second solution provides a process for machining in a chip forming way outer joint parts and inner joint parts of constant velocity universal ball joints which comprise a longitudinal axis Aa, Ai and a number of ball tracks, wherein the balls tracks are circumferentially arranged in pairs whose track center lines are positioned in planes E₁, E₂, E₃, E₄ extending parallel relative to one another, wherein

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the pairs of ball tracks are machined by rotating finger tools whose axes of rotation R intersect the respective longitudinal axis Aa, Ai in pairs symmetrically relative to one another at a distance from one another and whose axes of rotation R are held and guided in pairs and parallel relative to one another.

[0010] A third solution deviating insubstantially from the second solution provides a process for machining in a chip forming way outer joint parts and inner joint parts of constant velocity universal ball joints which comprise a longitudinal axis Aa, Ai and a number of ball tracks, wherein the balls tracks are circumferentially arranged in pairs whose track center lines are positioned in planes E₁, E₂, E₃, E₄ extending parallel relative to one another, wherein the pairs of ball tracks are machined by rotating finger tools whose axes of rotation R intersect the respective longitudinal axis Aa, Ai in pairs symmetrically relative to one another at a distance from one another and whose axes of rotation R are arranged and guided in pairs at a constant angle relative to one another. Both with the disc tools and with the finger tools, the track cross-section is defined by the tool profile in a section through the axis of rotation. Whereas the axis of rotation of the disc tools is aligned at a distance from and transversely to the longitudinal track extension, the axis of rotation of finger tools is aligned substantially perpendicularly relative to the track base. With disc tools, both track flanks are thus machined in the same cutting direction, whereas with finger tools, the two track flanks are machined in opposed cutting directions.

[0011] Analogously to the process mentioned first, with the further processes using finger tools, during the chip-forming machining operation, the outer joint parts and inner joint parts can be guided linearly in the direction of their respective longitudinal axis Aa, Ai and the axes of rotation R of the finger tools, during the chip-forming machining operation, can be guided synchronously and in movements with constant angles relative to one another in such a way that an axis of symmetry Rs positioned between the axes of rotation R is guided in a linear and/or pivoting movement radially relative to the respective longitudinal axis Aa, Ai. In this case, too, for the purpose of increasing production, at least two pairs of ball tracks – more particularly radially opposed pairs of ball tracks of an inner joint part – can be machined simultaneously. With outer joint parts, machining at least two pairs can be difficult because of the available space.

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[0012] With reference to providing suitable devices, the rotating finger tools are driven in pairs at identical speeds. The directions of rotation can be identical or opposite to one another.

[0013] For carrying out the process mentioned first, there is provided a device for machining in a chip-forming way the ball tracks of outer joint parts and inner joint parts, which device comprises one clamping device for an outer joint part or an inner joint part as well as two disc tools whose axes of rotation R extend coaxially relative to one another and which intersect the respective longitudinal axis Aa, Ai of the outer joint part or inner joint part perpendicularly at a distance from one another. To simplify the movements, according to a first embodiment the clamping device comprises a feeding device for ensuring axial feeding in the direction of the respective longitudinal axis Aa, Ai, and the driving device for the disc tools 16, 26 comprises only a feeding device for feeding the disc tools radially relative to the respective longitudinal axis Aa, Ai. Alternatively, the clamping device comprises a feeding device for ensuring axial feeding in the direction of the respective longitudinal axis Aa, Ai, and the driving device for the disc tools 16, 26 comprises only a pivoting device for pivoting the disc tools 16, 26 around a pivot axis intersecting the respective longitudinal axis Aa, Ai. In both cases, the mechanisms for carrying out the movements can be reduced considerably and thus become more cost-effective. More particularly, for changing the machining operation from one pair of tracks to the next pair of tracks the clamping device for the outer joint part or inner joint part is associated with a rotary drive, whereas the tools, with reference to the longitudinal axis, are arranged circumferentially fixed.

[0014] Furthermore, at least two disc tools comprise a common rotary drive. More particularly, at least two disc tools are produced so as to be integral with one another.

[0015] For carrying out the above-mentioned process mentioned first, there is provided a device for machining in a chip-forming way the ball tracks of outer joint parts and inner joint parts, which device comprises one clamping device for an outer joint part or an inner joint part as well as at least two rotating finger tools whose axes of rotation R extend parallel relative to one another and intersect the respective longitudinal axis Aa, Ai in pairs symmetrically relative to one another at a distance from one another; or it comprises a clamping device for an outer joint part or an inner joint part as well as at least two rotating finger tools whose axes of rotation R form a

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fixed angle relative to one another and intersect the respective longitudinal axis Aa, Ai in pairs symmetrically relative to one another at a distance from one another. Equally, for the purpose of simplifying and reducing the moving mechanism, as an alternative, the clamping device comprises a feeding device to ensure axial feeding in the direction of the respective longitudinal axis Aa, Ai, and the driving device for the finger tools comprises only a feeding device for feeding in the finger tools radially relative to the respective longitudinal axis Aa, Ai. Alternatively, the clamping device comprises a feeding device to ensure axial feeding in the direction of the respective longitudinal axis Aa, Ai, and the driving device for the finger tools comprises only a pivoting device for pivoting the finger tools around a pivot axis intersecting the respective longitudinal axis Aa, Ai. A further simplification can be achieved if the at least two finger tools comprise a common rotary drive. Such a common rotary drive for the finger tools can comprise more particularly a driven spur gear or bevel gear which engages spur gears which are positioned on the tool axes and are firmly connected with the finger tools.

Brief Description Of The Drawings

[0016] Preferred embodiments of the inventive process which include inventive devices are illustrated in the drawings and will be described below.

[0017] Figure 1 shows a process for machining in a chip-forming way ball tracks in an outer joint part by disc tools:

- A) in a longitudinal section through the longitudinal axis of the outer joint part; and
- B) in a cross-section through the longitudinal axis of the outer joint part.

[0018] Figure 2 shows a first embodiment of a process for machining in a chip-forming way ball tracks in an inner joint part by disc tools:

- A) in a longitudinal section through the longitudinal axis of the inner joint part; and
- B) in a cross-section through the longitudinal axis of the inner joint part.

[0019] Figure 3 shows a process of machining in a chip-forming way ball tracks in an inner joint part in a cross-section through the longitudinal axis of the inner joint part by disc tools.

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[0020] Figure 4 shows a process of machining in a chip-forming way the ball tracks of an outer joint part by axis-parallel finger tools:

A) in a first longitudinal section through the longitudinal axis of the outer joint part; and

B) in a second longitudinal section through the longitudinal axis of the outer joint part, extending perpendicularly thereto.

[0021] Figure 5 shows a first embodiment of a process of machining in a chip-forming way the ball tracks of an outer joint part by finger tools enclosing an angle:

A) in a first longitudinal section through the longitudinal axis of the outer joint part; and

B) in a second longitudinal section through the longitudinal axis of the outer joint part, extending perpendicularly thereto.

[0022] Figure 6 shows a process of machining in a chip-forming way the tracks of an outer joint part by finger tools enclosing an angle, in an embodiment according to Figure 5:

A) in a longitudinal section through the longitudinal axis of the outer joint part; and

B) in an axial section through the longitudinal axis of the outer joint part.

[0023] Figure 7 shows a second embodiment of a process of machining in a chip-forming way the ball tracks of an outer joint part by finger tools enclosing an angle:

A) in a first longitudinal section through the longitudinal axis of the outer joint part; and

B) in a second longitudinal section through the longitudinal axis of the outer joint part, extending perpendicularly thereto.

[0024] Figure 8 shows a process of machining in a chip-forming way the ball tracks of an inner joint part by finger tools forming an angle, comprising a first embodiment of a device in a cross-section through the longitudinal axis of the inner joint part.

[0025] Figure 9 shows a process of machining in a chip-forming way the ball tracks of an inner joint part by finger tools enclosing an angle, comprising a second embodiment of a device in a cross-section through the longitudinal axis of the inner joint part.

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Detailed Description

[0026] Figure 1 whose illustrations will be described jointly below shows an outer joint part 11 which is provided for a so-called twin ball joint comprising circumferentially distributed ball tracks 12_1 , 12_2 arranged in pairs around the circumference in such a way that their track center lines extend in parallel planes E_1, E_2, E_3, E_4 arranged in pairs. Furthermore, the outer joint part 11 is shown to comprise a joint base 13 and a joint aperture 14. Between the ball tracks 12_1 , 12_2 there are provided guiding webs 15_1 , 15_2 of different widths which form part of an inner spherical guiding face for a ball. Whereas the width of the guiding face 15_1 between a pair 12_1 , 12_2 of ball tracks remains substantially constant in the longitudinal direction, the width of the guiding face 15_2 between different pairs of ball tracks changes in the longitudinal direction, which is known in itself. In contrast to standard joints wherein the individual ball tracks are positioned in radial planes, as a result of which the circumferential distance between the individual ball tracks constantly changes in the longitudinal direction, the circumferential distances between the tracks 12_1 , 12_2 of the pairs of ball tracks 12_1 , 12_2 of a joint of the type described here are constant in the longitudinal direction.

[0027] Because of the way in which the ball tracks extend, it is possible for them to be machined in the manner described here by pairs of rotating disc tools 16_1 , 16_2 whose axes of rotation R_1, R_2 extend coaxially and, in this case, are held in a common holding device 17. The holding device 17 is only partially shown because, by necessity, it has to be connected to a drive which extends through the joint aperture 14 into the outer joint part 11. The rotating drive of the disc tools 16_1 , 16_2 can be effected by a belt drive for example. According to a preferred embodiment of the process, the outer joint part 11, during the mechanical production of a pair of tracks, is displaced only on the longitudinal axis Aa in the direction of the axis Z, while the holding device 17 carries out an entirely transverse movement perpendicularly to the longitudinal axis Aa in the direction of axis X characterized by a double arrow, so that the disc tools 16_1 , 16_2 have to be displaced. After the chip-forming machining operation carried out on a pair of tracks has been completed, the holding device 17 can be displaced radially or the outer joint part can be displaced axially to such an extent that the disc tools leave the respective pair of tracks completely. Thereafter, the clamping device for the outer joint part 11 (not shown here) can be rotated by the pitch angle between the pairs of tracks 12_1 , 12_2 , in the

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present case by 90°. This can be followed by a further pair of tracks being machined in a chip-forming way. Said operation is repeated, four times in the present case, until all pairs of tracks 12₁, 12₂ have been machined. In this case the machining operation can be milling or grinding.

[0028] Figure 2 shows an inner joint part 21 of a joint whose parallel tracks are arranged in pairs (twin ball joint) being machined in a chip-forming way. The pairs of tracks are designed in such a way that their center lines extend in planes E₁, E₂, E₃, E₄ which extend parallel relative to one another. In this case, too, guiding webs 25₁ are arranged between the tracks of a pair and guiding webs 25₂ between the tracks of two adjoining pairs, which webs form part of an externally spherical face on which a ball cage of a mounted constant velocity ball joint can be guided. The inner joint part 21 comprises a central aperture 23 with inner shaft teeth 24 for inserting a driving journal. In a longitudinal section, groups of arrows 28, 29, 30 indicate the holding forces of a clamping device which engages the aperture 23. The machining operation can be a milling or grinding operation.

[0029] The above-mentioned design of the pairs of tracks 22₁, 22₂, in this case, too, makes it possible to carry out a chip-forming machining operation in the preferred way in which two pairs of rotating disc tools 26₁, 26₂ and 26₃, 26₄ engage radially opposed pairs of tracks 22₁, 22₂. With this type of machining process, the inner joint part 21 is fed forward entirely in the direction of the axis Z, whereas the holding devices 27₁, 27₂ for the rotating disc tools 26₁, 26₂ and 26₃, 26₄ which comprises a corresponding driving mechanism move entirely in the X-direction perpendicularly to the longitudinal axis A_i of the inner joint part 21. The axes of rotation R₁, R₂ as well as R₃, R₄ extend in pairs coaxially and perpendicularly, at a distance, relative to the longitudinal axis A_i of the inner joint part 21. After the machining operation on two radially opposed pairs of tracks, which is illustrated in the drawing, the rotating disc tools 26 have to be disengaged from the track; thereafter, the clamping device of the inner joint part 21 has to be rotated by the pitch angle between the individual pairs of tracks, in the present case once by 90° to be able to repeat the machining operation on the two further pairs of tracks in the same way. Thereafter, i.e. after only two machining operations have been carried out for the entire inner joint part 21, the process of machining the ball tracks 12 is completed. The individual machining operations can be milling or grinding.

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[0030] In Figure 3, details identical to those in Figure 2 have been given the same reference numbers, and to that extent, reference is made to the description of same. The inventive process of machining pairs of ball tracks in a chip-forming way takes place simultaneously on all four existing pairs of tracks of the ball tracks 22₁, 22₂. For this purpose, the device used, in addition to the holding devices and driving devices 27₁, 27₂ for the pairs of rotating disc tools 26₁, 26₂ and 26₃, 26₄ comprises two further holding devices and driving devices 27₃, 27₄ with further pairs of rotating disc tools 26₅, 26₆ and 26₇, 26₈. The respective axes of rotation of said additional holding devices and driving devices have been given the reference symbols R₅, R₆ and R₆, R₇. In a device of this type, the clamping device for the inner joint part 21 does not require the driving mechanism for rotation. In this embodiment, the machining of all the ball tracks 22₁, 22₂ of the inner joint part 21 takes place in one single operating phase. During the machining of the pairs of tracks 22, the holding devices 27₁, 27₂ and 27₃, 27₄ are moved perpendicularly to the longitudinal axis A_i, which is indicated by the double arrows X₁, X₂ and X₃, X₄, these operations taking place simultaneously with the forward feed of the inner joint part 11 on the longitudinal axis A_i.

[0031] Figure 4 shows an outer joint part according to Figure 1 while the machining operation takes place on the ball tracks 12 by way of axis-parallel finger tools. Identical details of the outer joint part 11 have been given the same reference numbers as in Figure 1. Thus, reference is made to the description of same. For machining one pair of ball tracks 12₁, 12₂ there is provided a pair of rotating finger tools 36₁, 36₂ which are received in a common holding device and driving device 37 and whose axes of rotation R₁₁, R₁₂ are arranged parallel relative to one another. To allow a movement along the entire track extension of the pairs of tracks through the aperture 14 of the inner joint part 11, the axis of symmetry R_s between the axes 36₁, 36₂ forms an acute angle with the longitudinal axis A_a of the outer joint part 11. The forward feed of the clamping device for the outer joint part 11 is symbolized by the double arrow Z. A double arrow X extending perpendicularly relative to the longitudinal axis A_a indicates the simultaneous forward movement of the holding device 37. Instead of the latter forward movement or in addition thereto, there can be provided a pivot drive for the holding device 37 by which it is possible to continuously change the angle between the axis of symmetry R_s and the longitudinal axis A_a according to Figure 4B. When machining the pair of tracks in the way

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illustrated here, the pair of finger tools 36_1 , 36_2 has to be disengaged from the corresponding pair of tracks 12_1 , 12_2 , and the clamping device for the outer joint part 11 or the holding device and driving device 37 of the finger tools 36_1 , 36_2 has to be rotated by the pitch angle of the pairs of tracks, i.e. by 90° , around the longitudinal axis Aa. Preference is given to the rotation of the clamping device of the outer joint part 11.

[0032] Figure 5 shows a further process of and device for machining the ball tracks 12 of an outer joint part 11, wherein the finger tools $36_1'$, $36_2'$ are held in a common holding device 37', with their axes of rotation R_{11}' , R_{12}' enclosing an angle relative to one another. This angle has to be acute enough for the finger tools $36_1'$, $36_2'$ to be able to pass through the aperture 14 of the outer joint part 11 and move along the entire length of the ball tracks 12_1 , 12_2 . As far as the remaining details of the outer joint part are concerned, reference is made to the description of Figure 1. The finger tools can be driven jointly by a bevel gear whose axis of rotation is positioned on the axis of symmetry Rs' between the two axes of rotation R_{11}' , R_{12}' of the two finger tools $36_1'$, $36_2'$. As already described several times, the outer joint part 11, for machining purposes, can be moved in the direction of the double arrow Z radially relative to the longitudinal axis Aa. After a pair of tracks 12_1 , 12_2 has been machined, the finger tools are disengaged from the respective pairs of tracks and the outer joint part 11 and the holding device 37' are rotated relative to one another by a pitch angle between the pairs of tracks 12_1 , 12_2 , i.e. by 90° in the present case. It is preferred and the process is easier to carry out if there is provided a rotary drive for the clamping device of the outer joint part 11. The machining operations can be either milling or grinding.

[0033] Figure 6 shows the device according to Figure 5 with reference to a modified process for machining the ball tracks 12 of an outer joint part 11, wherein the finger tools $36_1'$, $36_2'$ are held in a common holding device 37' and whose axes of rotation R_{11}' , R_{12}' enclose an angle relative to one another. This angle has to be acute enough for the finger tools $36_1'$, $36_2'$ to be able to pass through the aperture 14 of the outer joint part 11 and move along the entire length of the ball tracks 12_1 , 12_2 . As far as the remaining details of the outer joint part are concerned, reference is made to the description of Figure 5. The finger tools can be driven jointly by a bevel gear 38 whose axis of rotation is positioned on the axis of symmetry Rs' between the two axes of rotation R_{11}' , R_{12}' of the two finger tools $36_1'$, $36_2'$. Hereafter, for

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machining purposes, the outer joint part 11 can be moved in the direction of the double arrow Z along a longitudinal axis Aa, and it can additionally be rotated around a transverse axis Aq. After a pair of tracks 12₁, 12₂ has been machined, the finger tools are disengaged from the respective pairs of tracks and the outer joint part 11 and the holding device 37' are rotated relative to one another by a pitch angle between the pairs of tracks 12₁, 12₂, i.e. by 90° in the present case.

[0034] Figure 7 shows a further process of and device for machining the ball tracks 12 of an outer joint part 11, wherein the finger tools 36₁", 36₂", 36₃", 36₄" are held in a common holding device 37", with their axes of rotation R₁₁", R₁₂" enclosing identical angles relative to an axis of symmetry Rs". These angles have to be acute enough for the finger tools 36₁", 36₂", 36₃", 36₄" to be able to pass through the aperture 14 of the outer joint part 11 and move along the entire length of the respective ball tracks. As far as the remaining details of the outer joint part 11 are concerned, reference is made to the description of Figure 1. The finger tools can be driven jointly by a bevel gear 38 whose axis of rotation is positioned on the axis of symmetry Rs". As already described several times, the outer joint part 11, for machining purposes, can be moved along its longitudinal axis Aa, whereas the holding device 37" is moved radially relative to the longitudinal axis Aa. After two pairs of tracks 12₁, 12₂ have been machined, the finger tools are disengaged from the latter pair of tracks and the outer joint part 11 and the holding device 37" are rotated relative to one another by a pitch angle between the pairs of tracks, i.e. by 90° in the present case.

[0035] Figure 8 describes a process of machining the pairs of tracks of the ball tracks 22 of an inner joint part 21 whose details have been given the same reference numbers as in Figure 2. To that extent, reference is made to the description of same. For machining the pairs of tracks 22₁, 22₂, there are provided finger tools 46₁, 46₂ which are each received in independent holding devices and rotary driving devices 47₁, 47₂. The axes of rotation R₁₁', R₁₂' of the rotatably drivable finger tools 46₁, 46₂ again form an angle relative to one another which is preferably held constant during the entire machining operation. The movements during the chip-forming machining operation carried out on the pairs of tracks 22₁, 22₂ preferably take place in such a way that the inner joint part 21 is moved in the direction of its longitudinal axis Ai, i.e. along the repeatedly mentioned Z-direction, entirely axially, whereas the devices 47₁, 47₂ are moved in the X-direction, i.e. radially relative to the

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longitudinal axis A_i , in the direction of the axis of symmetry R_s' of the two axes of rotation R_{11}' , R_{12}' . After the chip-forming machining operation carried out on a pair of tracks 22_1 , 22_2 has been completed, the rotating finger tools 46_1 , 46_2 are disengaged from the machined pair of tracks, and the clamping device for the inner joint part 21 is rotated by the pitch angle between the individual pairs of tracks, i.e. 90° in the present case. Thereafter, the process is repeated, i.e. carried out four times in the same way for the four pairs of tracks shown here.

[0036] Figure 9 shows a process for machining the pairs of tracks 22 of an inner joint part 21, which largely corresponds to that shown in Figure 6. To that extent, reference is made to the drawing of the inner joint part and to the description of the process. However, Figure 9 deviates from Figure 6 in that two finger tools 46_1 , 46_2 are received in a common holding device 47 which comprises a bevel gear 48 forming a common drive for the rotating fingers tools 46_1 , 46_2 . The axes of rotation R_{11}' , R_{12}' of the finger tools 46_1 , 46_2 , in this case, too, form an angle relative to one another. The preferred movements of the inner joint part 21 and of the tools relative to one another take place in such a way that the inner joint part 21 is displaced only in the direction of its longitudinal axis A_i , i.e. in the Z-direction, whereas the tools are displaced radially relative to the Z-direction in the direction of the double arrow X, and, respectively, in the direction of the axis of symmetry R_s' between the axes of rotation R_{11}' , R_{12}' .

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